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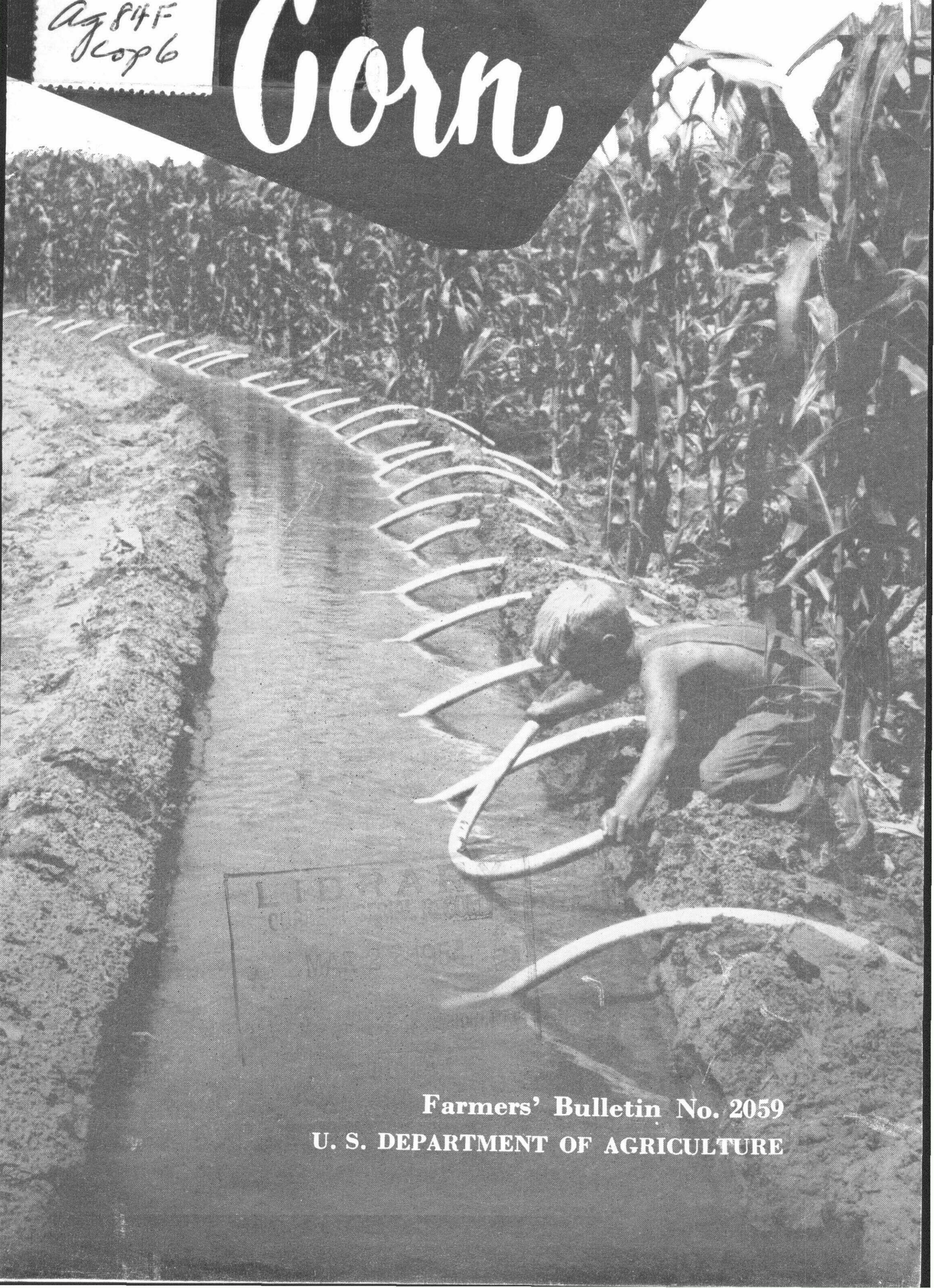
Irrigating Corn



Farmers' Bulletin No. 2059
U. S. DEPARTMENT OF AGRICULTURE

ANY FARMER KNOWS that corn needs good land and lots of water at the right time. With irrigation, corn can be grown in the arid and semiarid areas of the country where rainfall is below 15 inches a year. These areas contain some of the Nation's most fertile soils.

Irrigation will also increase corn yields in the humid areas by supplying water at the critical silking and tasseling stage when dry spells are common.

- Through irrigation you can produce corn more efficiently.
- By growing corn on the better land and with soil conservation practices, by applying water at the right time and in the right amounts, you get more efficient use of land and water.
- By increasing yields, you get more efficient use of your equipment and labor.

This bulletin points out the possibilities of irrigating corn, the methods, and the problems that irrigation may create.

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IRRIGATING CORN

By C. J. Francis, *regional engineer, and* J. W. Turelle, *soil conservationist, Northern Great Plains Region, Soil Conservation Service*

CORN is a warm-weather crop that needs plenty of water all through the growing season. With irrigation, corn can be grown even in arid and semiarid areas with less than 15 inches of rainfall.

The water needs of corn are greatest and most critical during silking and tasseling. The right amount of moisture at this time is so important to getting a good yield that even in humid areas, many farmers are finding it pays to irrigate corn.

Development of new corn hybrids is also expanding the use of irrigation of corn because hybrids often require more water to produce maximum yields.

HOW MUCH WATER DOES CORN NEED?

Corn does not need the same amount of water in all parts of the United States. Temperature, humidity, number of daylight hours, length of the growing season, rainfall, soil, condition of the land, and the skill of the irrigator all make a difference. Total water needs include water lost by evaporation, seepage, and waste, as well as that used by the plant.

In general, from 1 to 3 feet of water will be needed. In humid areas where only one irrigation may be required, less than 1 foot will do. Studies have shown that when corn is making its most rapid growth it will sometimes use as much as a half inch of water a day for a period of several days.

Rooting Habits of Corn

The objective in irrigating any crop is to keep the root zone well supplied with water at all times so that the plant can make complete use of the plant foods available in the soil.

Corn roots spread widely (fig. 1). They are thick and go deep. Their growth varies with the kind of soil, how well the soil gets air and water, and the amount of water in the soil.

Corn roots spread most and go deepest in well-drained, loamy soils. In such soils, they may spread to a width of 8 feet and penetrate to a depth of 6 feet. In dense clay soils and in shallow soils, they don't go so deep.

LAND ADAPTED TO IRRIGATION

You usually can irrigate corn safely on any productive soil if the surface slope is gentle enough so that water can be spread without erosion. Loam soils are the best because they hold lots of water and take water readily. Heavy clay soils also hold lots of water but they take the water slowly, and so require more time to irrigate. Sandy soils take water freely but don't retain much of it, making it necessary to irrigate more often.

The ideal soil for irrigated corn is a

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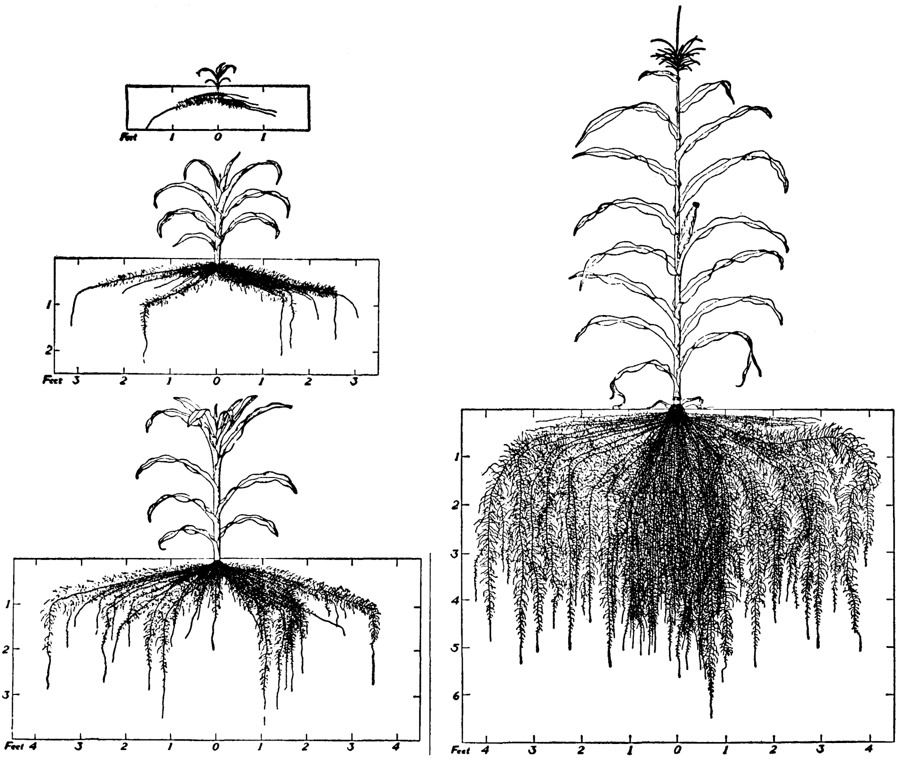


Figure 1.—**The stalk and root system of a corn plant at different stages of growth at the Nebraska experiment station. The soil is favorable for good root development. The roots do most of their spreading during early growth. After 6 weeks they move down to about 6 feet.**

good loam, 4 to 5 feet deep, underlain by well-drained sand or gravel. A soil of this kind gives the roots plenty of room and at the same time permits excess water to drain away without causing damage.

A tight layer of clay or hardpan below an otherwise good soil can slow the downward movement of water. If you apply too much, the extra water collects above the tight layer and gradually raises the water table so high that the roots are in saturated soil all the time.

You can check the kind of soil and subsoil by taking a few borings with a soil auger.

Corn cannot stand much alkali. If the alkali salts are soluble in water, they sometimes can be washed downward out of the root zone by applying extra irrigation water. To do this, the soil must have good underdrainage. If it is not naturally well drained, a properly designed drainage system should be installed. If you have any question as to the amount of alkali salts in the soil or water, send a sample to your land-grant college for testing.

If you plan to irrigate by the furrow method—letting the water flow down the rows—you will need to be more careful in selecting the land,

particularly with regard to the slope. The slopes should be continuous in one direction so that the water can run the full length of the furrow and not form ponds.

Some slope is necessary to make the water flow, but it should not be too steep—usually between 0.1 and 3 percent (1⅛-inch to 3-foot drop per 100 feet). Where the slope of the rows is greater than this, the water will move so fast that it will erode the soil. In areas that have heavy rains, the slope will have to be more nearly flat or special conservation practices will have to be applied to prevent washing.

PREPARING LAND FOR IRRIGATION

If you are to apply water evenly over a field with as little work as possible, the field should be free from high and low spots. It should have enough slope to let the water flow across it. Not many fields meet these requirements in their natural condition or even if they have been farmed for a long time. This means that you will probably have to do some smoothing or "leveling."

In planning your irrigation system and the leveling necessary, a good topographic map will help you determine which way to run the water, where to put the ditches, and how to arrange the fields. Your soil conservation district can help you solve these problems.

Before you decide to smooth a field you will need to study the soil, particularly the depth of good soil. After you know the topsoil depth, you can then decide how much soil you can cut from one place in order to fill another. Do not level a field where you would expose large areas of infertile subsoil. You may have to expose some of it. But if the exposed areas are small, you can treat them by putting on plenty of manure and fertilizer.

In planning your irrigation system, don't forget the other crops that will be grown in the rotation. Close-growing crops need smoother ground for good irrigation than does corn.

Land-leveling equipment has been improved greatly within recent years, and the cost of leveling has gone down. Usually, costs range from $15 to $75 per acre. This covers the moving of 75 to 400 cubic yards of earth per acre.

Most leveling jobs can be done for the lowest overall cost by using heavy earth-moving equipment. Specialized equipment is best because large amounts of earth must be moved a considerable distance (fig. 2). You can use a farm tractor but the job will take longer.

The finishing job should be done with a float or a landplane. These can be attached to either farm tractors or heavy track-type tractors, depending on the size of the job and the equipment you have available.

In any event, you should have some land-smoothing equipment that can be pulled with the farm tractor. You will need it from time to time to smooth out rough places caused by regular farming operations or by erosion. You may also need it to finish up uneven places caused by settling after the heavy work is done on a field. These jobs are a necessary part of the land care in irrigation farming. You will find you need to

Figure 2.—**Heavy equipment is used for most land-leveling jobs because of the large amount of earth moved.**

smooth your land about as regularly as you plow.

Constructing Farm Ditches

Water is distributed to fields by a system of open ditches, by a system of pipes, or by a combination of both. The ditches can be either permanent or temporary. Pipes may be installed permanently underground, or may be portable and on the surface.

Permanent ditches are usually built along the edges of fields. They carry water from the source to the high point on each of the various fields on the farm. Structures such as checks, drops, siphons, ditch lining, flumes, and turnouts may be needed to get the water to the different fields without loss or erosion.

Temporary ditches are plowed in cultivated fields each year. They are then leveled down so that the crops can be harvested more easily. The number you need depends on the slope, the kind of soil, and the amount of water the crop needs.

Water should not flow so fast that it erodes the ditch. On the other hand, it should not flow so slowly that large, expensive channels are needed.

The average permanent farm ditch, used where corn is grown as a part of the rotation, carries about 2 cubic feet of water per second, or 900 gallons per minute.

You can get this flow on a grade of 1¼ inches per 100 feet with a stream 6 inches wide at the bottom, 3½ feet wide at the surface, and with water flowing 12 inches deep. The ditch should be deep enough so that you get the amount of water you need without the water level rising higher than within 6 inches of the top of the

ditchbanks. Most temporary ditches are built with grades ranging from ½ inch to 3 inches per 100 feet. You may have to run the ditch at a very flat grade to serve the most land possible. But the flatter the grade, the larger must be the ditch to carry a given amount of water. Generally, temporary ditches are run at a flat grade because water is easier to handle when it is flowing slowly.

You can build small farm ditches by plowing several furrows with a moldboard plow. Then use a small V-shaped ditcher to shape the channel (fig. 3). Medium-sized ditches may be made with wingplows, graders, or ditching machines.

Keep ditches clean. They usually need cleaning early in the spring and may need it occasionally during the season.

Water-Control Structures

Structures are needed in permanent ditches to help with the distribution of water. You sometimes need them to prevent erosion, to reduce loss by seepage, and to carry water to places that cannot otherwise be reached by a gravity ditch.

Where erosion or seepage is not a problem and where the slope of the land will permit the use of a gravity ditch to all parts of the farm, you may be able to irrigate without any permanent structures. Canvas dams, for checking water in the ditch, and siphons can be used to let water into the corn furrows. All of this equipment can be moved from one place to another as needed.

To prevent erosion, drop structures are best adapted for use in ditches

Figure 3.—**Small farm ditches can be made with a ditcher and the regular farm tractor.**

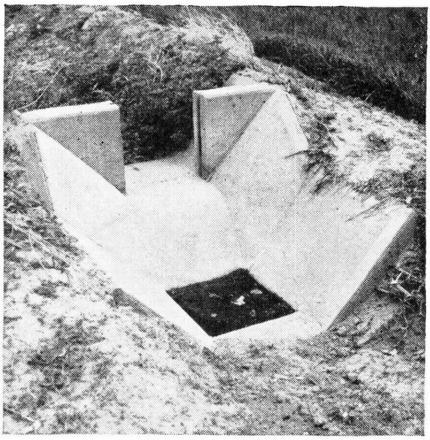


Figure 4.—**Small concrete drop structures are used to prevent erosion in ditches where the slope is not too steep.**

where the slope is not more than 5 percent (fig. 4). On steeper slopes, you will find it cheaper to line the ditch with concrete (fig. 5), or to lower the water through a pipe.

If you use drop structures and they are close together, set them so that the height of the apron of one structure is level with the crest of the next one downstream. Drops of 6 to 24

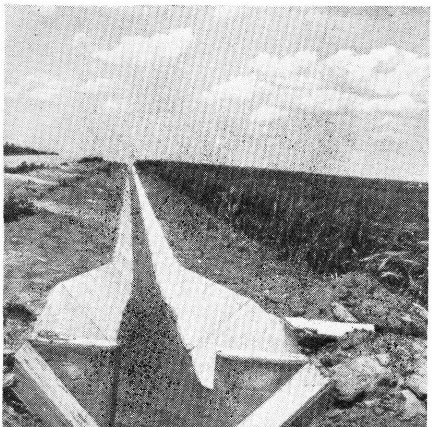


Figure 5.—**This ditch, built on a steep slope, is lined with concrete to prevent erosion.**

inches have been found most satisfactory. Except on steep slopes, drops of more than 24 inches are not widely used. This is because the ditches below each structure would have to be deep.

Permanent ditch structures are built of concrete, steel, treated wood, or pipe, depending on material available and the needs of the system.

Seedbed Preparation

A friable, firm seedbed is necessary for good corn production. The methods you use for planting dryland corn are generally satisfactory for irrigated corn.

Fertility requirements for irrigated corn are considerably higher than for dryland corn, and larger quantities of commercial fertilizer, especially nitrogen, should be used. Also, to obtain maximum yields, corn should be planted thicker, as more plants per acre are required to make most efficient use of the irrigation water.

You can get information about the kinds and amounts of fertilizer to use and how thick to plant the corn in your area from your county agent or soil conservation district.

METHODS OF IRRIGATING CORN

You irrigate corn either by letting the water flow down the rows (furrow irrigation) or by applying the water over the entire surface through sprinklers. Both methods have advantages.

Furrow Irrigation

There are three ways to lay out a field for furrow irrigation. Run the rows (1) down the slope, (2) across

the slope, or (3) on the approximate contour, depending on the slope of the fields.

The usual method is to run the rows directly down the slope. This is the simplest method to use if you can prevent erosion from the irrigation water and if erosion from rainfall is not a problem. You can control erosion on slopes up to 2 to 3 percent by carefully controlling the amount of water flowing into each furrow.

On steeper slopes you will need to run the rows at an angle to the slope or lay them out on the contour. The contour method of irrigating row crops is discussed in Leaflet 342, Contour-Furrow Irrigation.

Running the rows across the slope to cut down the steepness of the grade in the furrow is a good idea but you can't always do it. The field must be smooth enough so that each row can have a continuous downhill grade. If there is a section of uphill grade in one or two furrows over which it cannot pass, the water will overtop these furrows and wash out the adjoining ones below.

Since the grade is steepest directly down the slope, this overflow water will flow straight down the slope and no water will get to the land beyond the point of the break. For this reason, you will need a careful survey of the field before you decide to run the furrows across the slope. You can get help on this from your soil conservation district.

In areas of high rainfall, rains that come after the corn is laid by may cause breaks in the furrows, and since the corn is large, it is not easy to repair the damage and put on more water. There are, however, real advantages to irrigating across the slope or on the contour; where runoff from rain is not usually a problem, you will want to use these methods if possible.

Length of run

In irrigating most fields, don't try to supply all the water from one ditch. If you do, you will overirrigate the upper part of the field in order to get enough water on the lower part. You also run the risk of erosion in the furrows, because of the large amount of water needed at the upper end to push the stream the length of the furrow.

To avoid this risk, plow out additional temporary ditches to divide the field into several parts. The spacing depends on the slope and the soil. The best way to decide the right spacing for the temporary ditches is by studying the field during an irrigation. The following tabulation is a guide for use in starting your study:

Kind of soil:	*Length of run (feet)*
Heavy clay to sandy clay	525 to 850
Clay loam to silt loam	450 to 700
Loam to sandy loam	350 to 600
Loamy fine sand to sandy	125 to 400

These runs are based on a furrow slope of 1 percent. On flatter slopes they may be longer, but on steeper slopes you must cut down the length of run and amount of flow. In any case, you should check by field observation during irrigation.

Taking water from field ditches

There are several ways of taking water from the field ditches and putting it in the individual furrows. All of them must provide for controlling the amount of water let into each furrow. Do not cut holes in the ditchbank and let the water run down the furrows uncontrolled because it may cause serious washing. You will also waste water and lose valuable plant nutrients and may build up a wet condition in the soil.

Irrigating with siphon tubes

Siphon tubes are widely used because they are easy to set and to move from one location to another (fig. 6). They are made of light metal, rubber, or plastic and can be bought in all irrigated areas. Some of the metal siphons have a gate at the lower end for controlling the flow.

With siphons you can take water directly from the field ditch without cutting the bank (see cover). They are easy to start. But, if the flow in the ditch stops, the siphon action stops and all the tubes must be started again.

The size of tube needed is largely controlled by the slope of the furrows. Sizes generally used vary from ¾-inch diameter for most 3-percent slopes, up to 2-inch diameter for slopes flatter than 0.5 percent. Many new irrigators make the mistake of buying tubes too large for their needs.

Some type of check is needed in the ditch to stop the water from flowing past the area where the siphon tubes are operating. Sometimes permanent-type structures are utilized, but more often a temporary check made of canvas or sheet metal

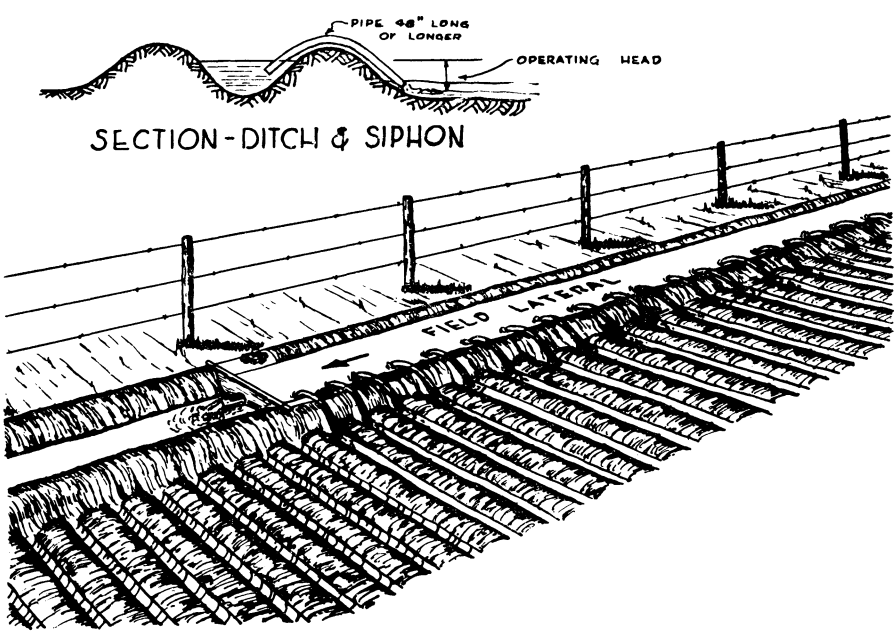


***Figure 6.*—This sketch gives the details of a siphon-tube layout.**

TABLE 1.—*Discharge for spiles operating under different heads*

[g. p. m.—gallons per minute]

Spile	Head in inches (height of water above intake)						
	1	2	3	4	5	6	9
	G. p. m.	*G. p. m.*	*G. p. m.*	*G. p. m.*	*G. p. m.*	*G. p. m.*	*G. p. m.*
Plastic tube:							
½-inch diameter	....	1.3	1.6	1.8	2	2.1	2.7
¾-inch diameter	....	3	4	5	5.5	6	7
1-inch diameter	....	4	5	7	8	9	11
1⅛-inch diameter	....	6	7	8	10	11	13
1¼-inch diameter	....	8	10	12	13	15	18
1⅜-inch diameter	....	10	13	15	17	19	23
1½-inch diameter	....	13	16	18	21	24	28
1⅝-inch diameter	....	15	18	22	25	28	33
1¾-inch diameter	....	17	21	25	28	32	38
1⅞-inch diameter	....	19	24	29	33	36	44
2-inch diameter	....	21	27	32	36	40	....
Lath box made of:							
Two 2½-inch boards and 2 laths	12	19	23	26	30	34	....
Two 2-inch boards and 2 laths	10	17	21	24	27	30	....
Four laths	6	9	11	13	15	17	....

is used. Most checks are built so that excess water can be bypassed. If your ditch has lots of grade, several of these may be needed to maintain the proper water level in the ditch.

The soil soaks up water fast when you first let it into a dry furrow, and it takes a lot of water to reach the end of the furrow in a reasonable length of time. After the furrow is wet, less water is needed to keep the flow even. In general, the amount of time needed for the water to flow to the end of the furrow should be about one-fourth of the time needed to irrigate the field. On the heavier soils on flat slopes, it is sometimes advisable to start with two siphons in each furrow and then cut back to one after the water has reached the end.

Table 1 shows the discharge in gallons per minute for plastic siphon tubes operating under different heads.

Irrigating with gated surface pipe

Lightweight metal pipe with small gates to match the furrows is becoming a popular method of irrigating corn (fig. 7). The pipe comes in sections easy for one man to handle. The pipes are fitted with simple, watertight connections that can be coupled together quickly. In using gated pipe, the inlet end of the pipe is mudded into the ditch upstream from a check dam.

With gated pipe there is no loss of water between the ditch and the furrows. Another advantage is that you can carry water down steep slopes in the pipes and release it in

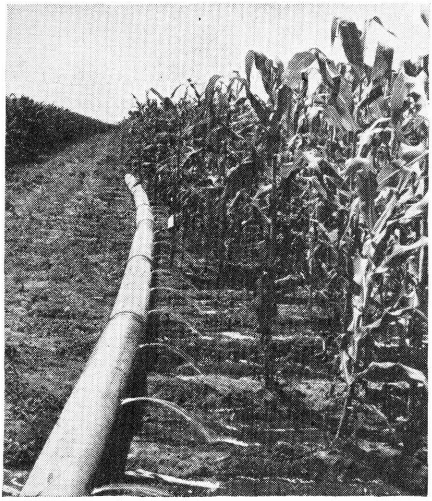


Figure 7.—**Lightweight gated pipe distributes water evenly.**

cross-slope or contour furrows. You can easily cut back the streams in the furrows by partly closing the gates in the pipe. This is usually done when the water reaches the end of the row.

The size of the pipe to use depends on the number of rows you plan to irrigate at one setting.

Lay pipe to cover enough rows to get over the field in the time required to keep an adequate supply of moisture in the ground.

Irrigating with an equalizing ditch and spiles

An equalizing ditch and spiles provide a good method of getting the right amount of water into the corn furrow (fig. 8). But it takes more work; you have to construct the equalizing ditch and you have to cut the bank to set the spiles. These ditches are called secondary ditches in some parts of the country.

The spiles can be made of lath, metal, rubber, or plastic. You can build takeout boxes of 1- x 6-inch boards about 3½ feet long. Cut a slot in the intake end to take a metal slide gate with which to control the flow (fig. 8). Close the outlet end of the takeout box, and provide openings in the sides to let the water out. This prevents the water from shooting straight out of the box and against the opposite bank of the ditch, where it might cause erosion.

Irrigating With Sprinklers

Sprinklers are one of the newer devices for irrigating corn.

The system must be properly designed, so it won't apply water faster than the soil can soak it up. You must also have a big enough system to get over the field often enough to keep an adequate supply of moisture in the ground.

Sprinklers most nearly imitate natural rainfall. Water must be kept under pressure, either by pumps or by getting it from a higher elevation, to operate a sprinkler system.

One way of setting up a sprinkler system is to place a stationary pump at the source of water and pipe the water to the fields. Another is to use portable pumps to take water from permanent ditches or ponds. In either case, lightweight pipe with couplers makes it easy to set up and take down the pipe.

Sprinklers, when properly designed and operated, have these advantages:

1. You can irrigate without danger of erosion. This lets you irrigate steeper land than you can by other methods.

2. You can put the water on fairly evenly. This is especially important on sandy soils where you often put too

much water on land near the field ditch in order to get enough on the rest of the field.

3. You don't waste much water. You don't lose water in ditches.

4. There is little or no need for land leveling. This makes it possible to irrigate shallow soils where leveling might be out of the question.

5. You don't need field ditches. This saves work and weed problems. More important, you can use the entire field for crops.

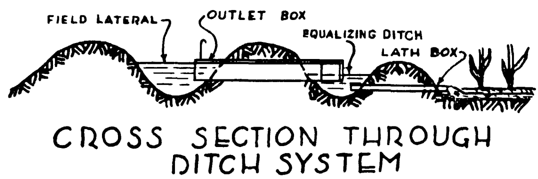
Disadvantages of sprinklers are:

1. The first cost is high. Also, sprinkler equipment wears out and must be replaced.

2. Wind may cause uneven distribution of water.

3. You must have a constant supply of water to make a sprinkler system work efficiently. And the water must be clean or the nozzles will clog.

4. It takes power. Sprinklers need from 15 to 100 pounds pressure per square inch.



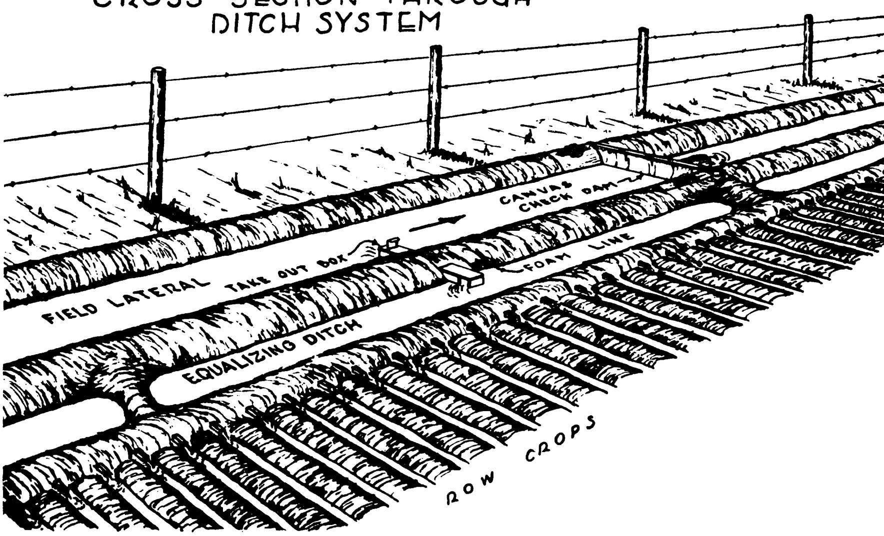


Figure 8.—To lay out an equalizing ditch and takeout, set a check dam partially blocking the flow of water in the field lateral in order to raise the water level. Cut the ditchbank with a shovel and put in a takeout box. Seal it with mud to prevent leakage. Open the gate in the takeout box to let the water enter the equalizing ditch. Watch for the foam line that forms. This is a guide for setting the spiles. Set each spile as nearly level as possible and close to the ground in the row. Seal the spiles into the ditchbank with mud. Set the gate in the check dam so that you maintain the height of water you want, as this level determines the amount that flows through the spiles. Keep the level of the water above the spiles to help prevent their clogging with trash. One takeout box will ordinarily serve from 12 to 20 spiles. After setting one ditch, repeat the process until the entire flow in the field lateral is used.

5. When the corn gets high, long extensions are needed to raise the sprinkler heads. These often must be braced. Also, it is not easy to move pipe from one setting to another in high corn.

WHEN TO IRRIGATE CORN

Corn needs plenty of water throughout the growing season. It can make good use of water until the grain is well dented.

The most common mistake farmers make in irrigating corn is to wait until it shows signs of needing moisture. If you wait until the leaves start to curl and dry, or in nearly mature corn to turn yellow, it is too late. Before these symptoms show up, you should determine the amount of moisture in the soil by digging and checking.

Not all the water in the soil is available for plants. The amount of readily available moisture varies in different kinds of soil. When half of the available soil moisture is used up, it is time to start irrigating. Table 2 explains how you can tell how much is left. You will want to check at different depths but go at least 3 feet deep for corn. Don't forget to allow for the time it takes to get over the field.

Figure 9 can be used in combination with table 2 to determine the amount of water needed to refill the soil to its moisture-holding capacity.

Let's assume that you plan to irrigate to a depth of 4 feet, which might be needed for corn in the deep soils of the Midwest. Let's also assume that the first 2 feet of soil are loam or medium soil, and the third and fourth feet are loamy fine sand or light soil. From the information at the bottom of the form, record in column 7 the amount of water in

1	2	3	4	5	6	7	8	9	10
Depth (feet)	Soil texture					Available moisture capacity	Soil moisture before irrigation		Moisture deficiency
	Very heavy	Heavy	Medium	Light	Very light				
						Inches	*Percent*	*Inches*	*Inches*
0-1			X			2.00	20	0.40	1.60
1-2			X			2.00	40	0.80	1.20
2-3				X		1.25	50	0.62	0.63
3-4				X		1.25	50	0.62	0.63
4-5									
5-6									
Total						6.50		2.44	4.06

Available moisture capacity in inches of water per foot depth of soil under average conditions: very heavy, 2.00; heavy, 2.20; medium, 2.00; light, 1.25; very light, 0.75.

***Figure 9.*—Form for figuring the amount of water needed to refill the soil to its moisture-holding capacity.**

Table 2.—*Guide for judging how much moisture is available for crops*

Soil moisture remaining	Feel or appearance of soil			
	Very light texture	Light texture	Medium texture	Heavy and very heavy texture
0 percent.....	Dry, loose single grained flows through fingers.	Dry, loose, flows through fingers.	Powdery dry, sometimes slightly crusted but easily broken down into powdery condition.	Hard, baked, cracked; sometimes has loose crumbs on surface.
50 percent or less.	Appears to be dry, will not form a ball with pressure.[1]	Appears to be dry, will not form a ball.[1]	Somewhat crumbly but holds together from pressure.	Somewhat pliable, will ball under pressure.[1]
50 to 75 percent.	Same as very light texture with 50 percent or less moisture.	Tends to ball under pressure but seldom holds together.	Forms a ball, somewhat plastic, will sometimes slick slightly with pressure.	Forms a ball, ribbons out between thumb and forefinger.
75 percent to field capacity (100 percent).	Tends to slick together slightly, sometimes forms a very weak ball under pressure.	Forms weak ball, breaks easily, will not slick.	Forms a ball; is very pliable; slicks readily if relatively high in clay.	Easily ribbons out between fingers, has slick feeling.
At field capacity (100 percent).	Upon squeezing no free water appears on soil but wet outline of ball is left on hand.	Same as very light texture.	Same as very light texture.	Same as very light texture.

[1] Ball is formed by squeezing a handful of soil very firmly.

inches readily available in each foot of soil. Add these up and you have the total water capacity of the soil to a depth of 4 feet.

Now move over to column 8 and from table 2 put in the percent of available moisture now in the different soil layers. You get this information by digging and checking with table 2. Multiply these percentages by the figures in column 7 and record the result in column 9. This is the amount of water in inches now available to the corn.

Subtract the figures in column 9 from those in column 7 and place the result in column 10. Add the figures in columns 9 and 10. Column 9 shows the amount the soil now contains; column 10 shows how much to add.

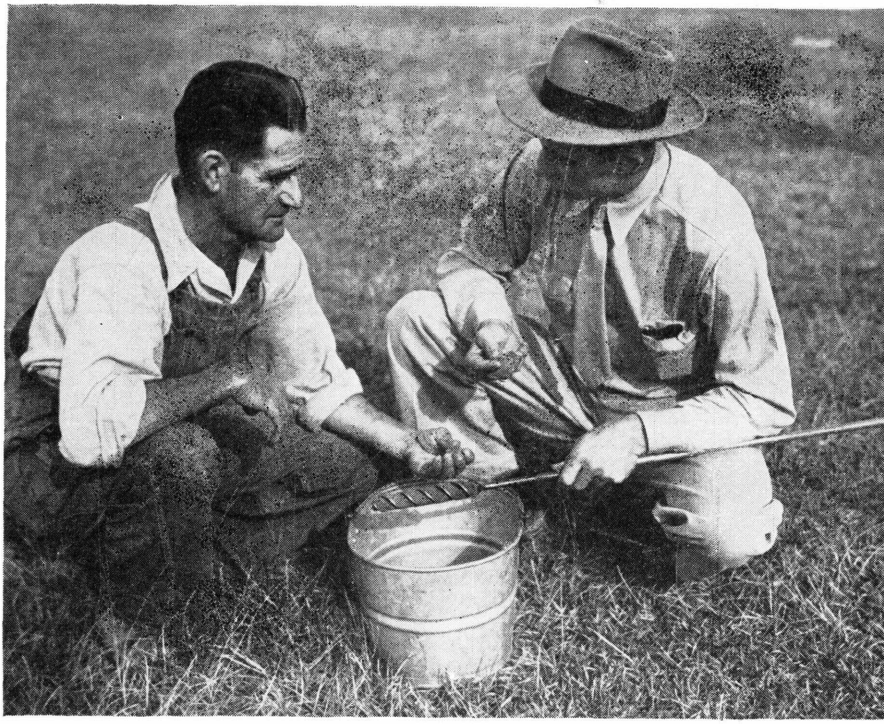


Figure 10.—**Use a soil auger both *during* and *after irrigation* to determine how far the irrigation water has soaked into the soil. The auger should be long enough for you to test the soil to the depth you need to go, and should have a T-handle so that you can turn it in the soil.**

If the total of column 9 is about half the total of column 7, it is time to irrigate.

How Well Are You Irrigating?

You need a soil auger to determine how effectively the water is penetrating the soil. An auger, like that shown in figure 10, is a necessary part of an irrigation farmer's equipment.

Make borings throughout the field during and after irrigation to determine the depth of water penetration Remember that it usually takes from 24 to 48 hours after irrigating for the water to reach its maximum depth in the soil.

If your borings show overirrigation at the upper end or underirrigation at the lower end, your runs are too long.

Know your soil, its water-holding capacity, and its intake rate, and *use your auger*. If you do these things, you will do a good job of irrigating

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